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Constraining neutron-induced processes with surrogate reactions in heavy-ion storage rings

Neutron-induced reaction cross sections of short-lived nuclei are essential in nuclear astrophysics and for applications in nuclear technology. However, these cross sections are very difficult or impossible to measure due to the difficulty in producing and handling the necessary radioactive targets. We are developing a project that uses for the first time surrogate reactions in inverse kinematics at a heavy-ion storage ring. This allows us to measure all the de-excitation probabilities as a function of the excitation energy of the nuclei formed through the surrogate reaction with unrivalled precision and indirectly determine the aforementioned cross sections.

In this contribution, I will present our new methodology and the results of the first two surrogate-reaction experiments that we have successfully performed at the ESR storage ring of the GSI/FAIR facility in Darmstadt, Germany. In these experiments we have investigated the (p,p'), (d,p) and (d,d') surrogate reactions and have achieved a significant breakthrough by measuring for the first time the fission, gamma-ray, neutron and even two- and three-neutron emission probabilities simultaneously. The measurement of all competing decay channels enables the precise determination of fundamental quantities, including fission barriers, particle transmission coefficients, gamma-ray strength functions, and nuclear level densities and employ them to infer (n,f), (n,gamma), (n,n'), (n,2n), and (n,3n) cross sections.

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